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Däumer et al.

[11] **4,414,946**

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[54] **CONTROL SYSTEM FOR AN OPERATING EVENT IN A VEHICULAR POWER TRAIN**

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[30] **Foreign Application Priority Data**

Jan. 14, 1981 [DE] Fed. Rep. of Germany 3100825

[51] **Int. Cl.**[3] **G06F 15/20**; G05B 15/02; F02D 5/02

[52] **U.S. Cl.** **123/417**; 123/414; 123/486; 123/416; 123/467

[58] **Field of Search** 123/414, 417, 418, 480, 123/416, 424, 486, 487; 364/200, 424, 442, 900, 431

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,178,893	12/1979	Aoki	123/416
4,244,339	1/1981	Gorille	123/416
4,250,858	2/1981	Jeenicke et al.	123/480
4,267,569	5/1981	Baumann et al.	123/417
4,304,256	5/1980	Klotzner	123/480
4,373,187	2/1983	Isbii et al.	123/480
4,603,539	12/1977	Gorille et al.	123/418

FOREIGN PATENT DOCUMENTS

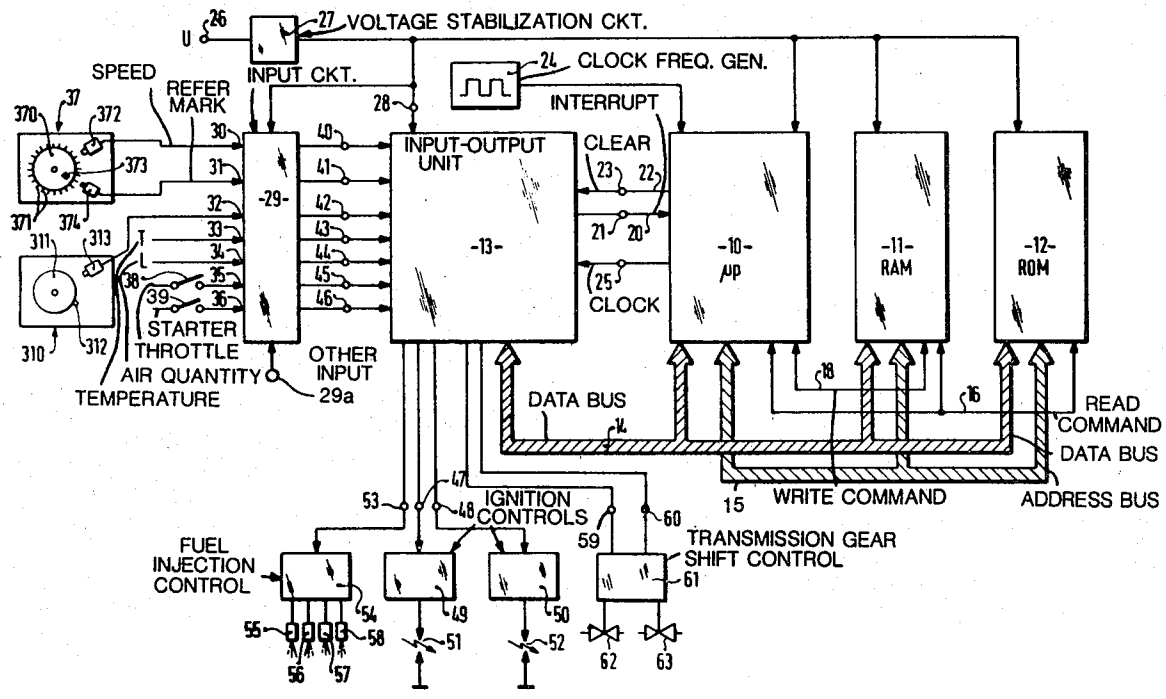
2900111 7/1980 Fed. Rep. of Germany 123/418

Primary Examiner—Raymond A. Nelli
Attorney, Agent, or Firm—Frishauf, Holtz, Goodman & Woodward

[57] **ABSTRACT**

To reduce the data processing requirements within operating cycles of an automotive-type microprocessor or computer, the input/output unit has an angle increment counter receiving angle increment signals synchronized with rotation of the crankshaft of the engine, the counter providing output signals to comparators which, when the count state reaches predetermined values as applied from a data bus, derived from the microprocessor, to the comparator, then provides output signals to control the engine, for example by providing ignition control output signals, fuel injection control output signals, or the like. To further simplify computational tasks of the microprocessor, the input/output unit contains a timing element, for example a counter, which can provide variable timing intervals, for example by controlling the clock rate of the counter or a count number, under control of the data bus, and a transfer switch which selectively applies to a further counter either the signals from the timing circuit or from the crankshaft angle increment counter so that, as desired, data then being processed in the microprocessor can be selectively based on or compared with engine speed, or predetermined timing intervals, for consequential control of other operating parameters of the engine and the entire power train system of which it is a part.

10 Claims, 3 Drawing Figures



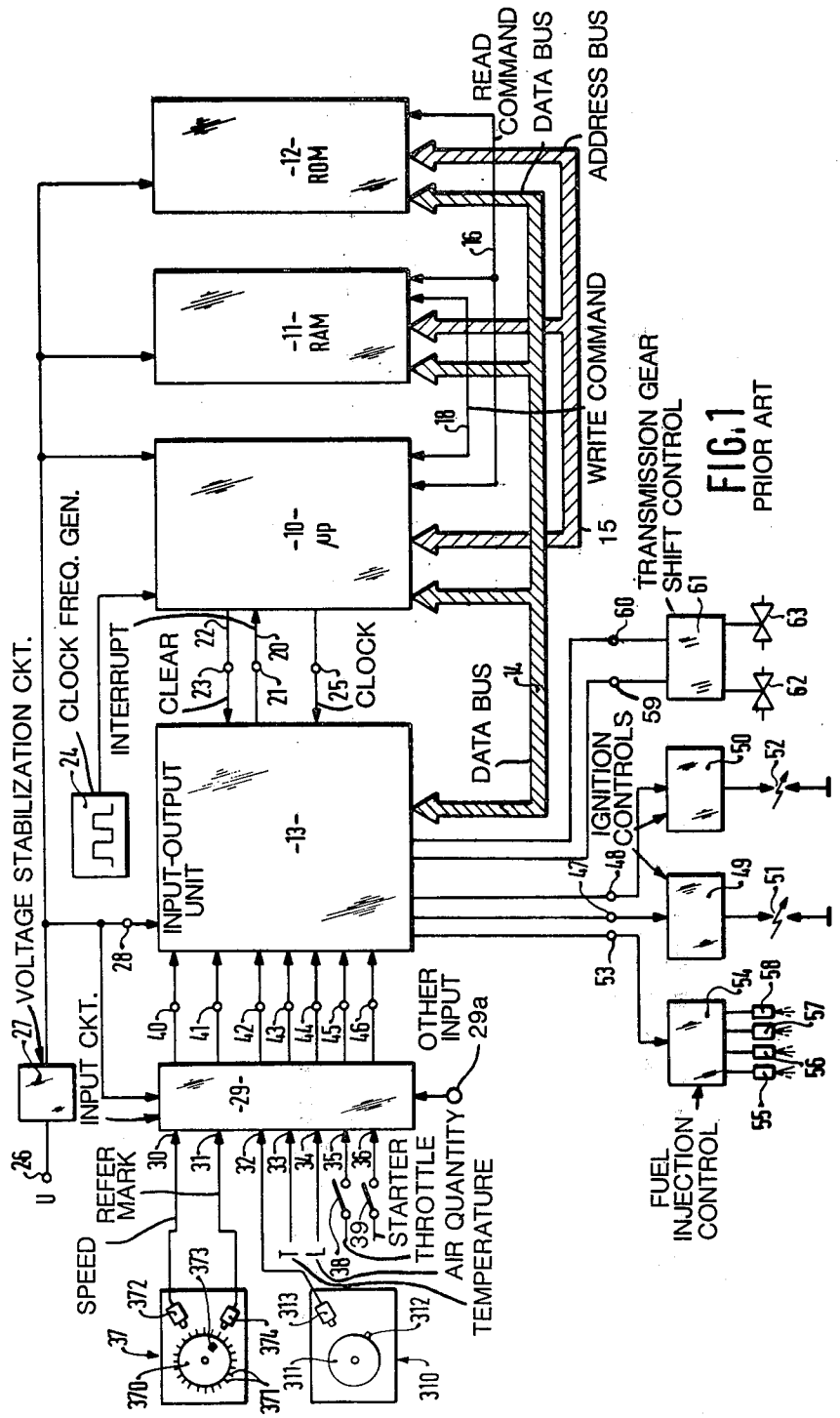


FIG. 1
PRIOR ART

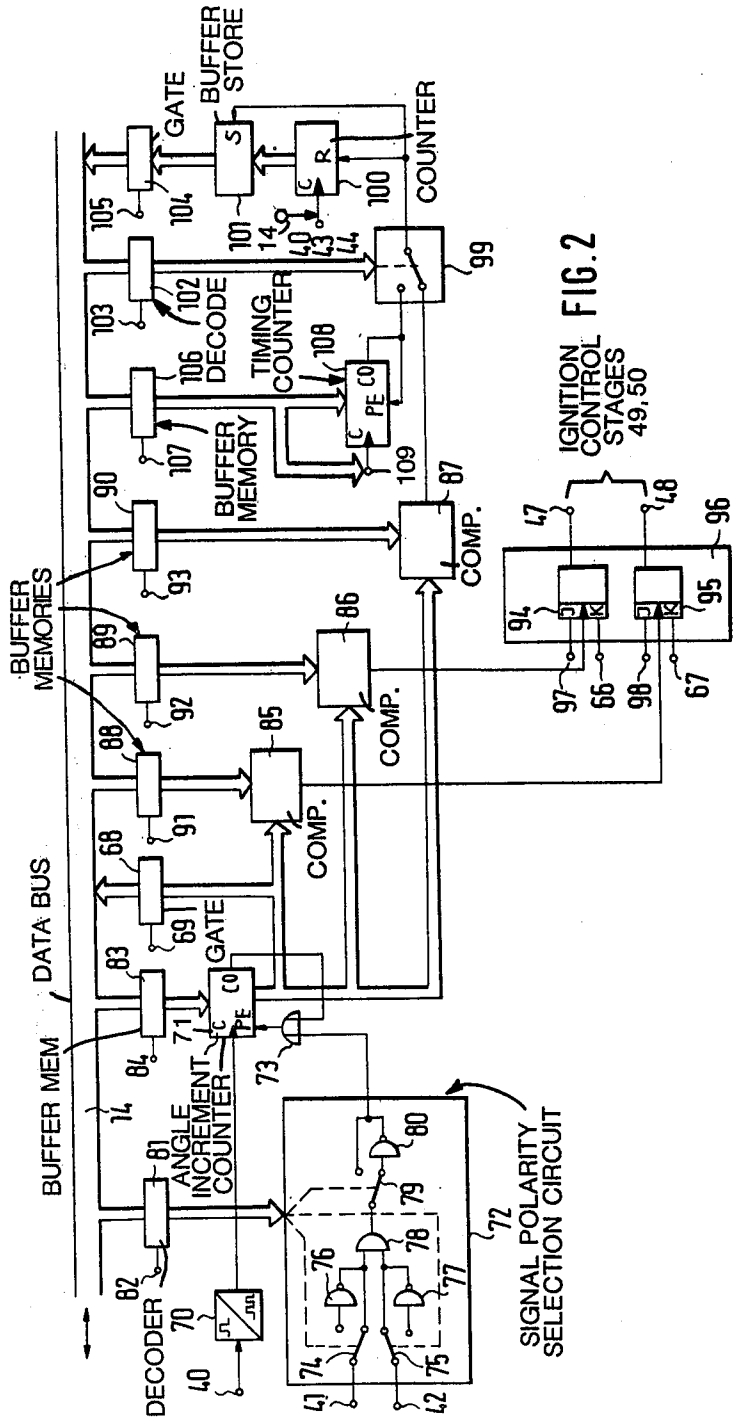

BUFFER STORE
GATE
COUNTER
DECODE
TIMING COUNTER
BUFFER MEMORY
BUFFER MEMORIES
COMP.
IGNITION CONTROL STAGES 49,50
DATA BUS
BUFFER MEM
ANGLE INCREMENT COUNTER
DECODER
SIGNAL POLARITY SELECTION CIRCUIT

FIG. 2

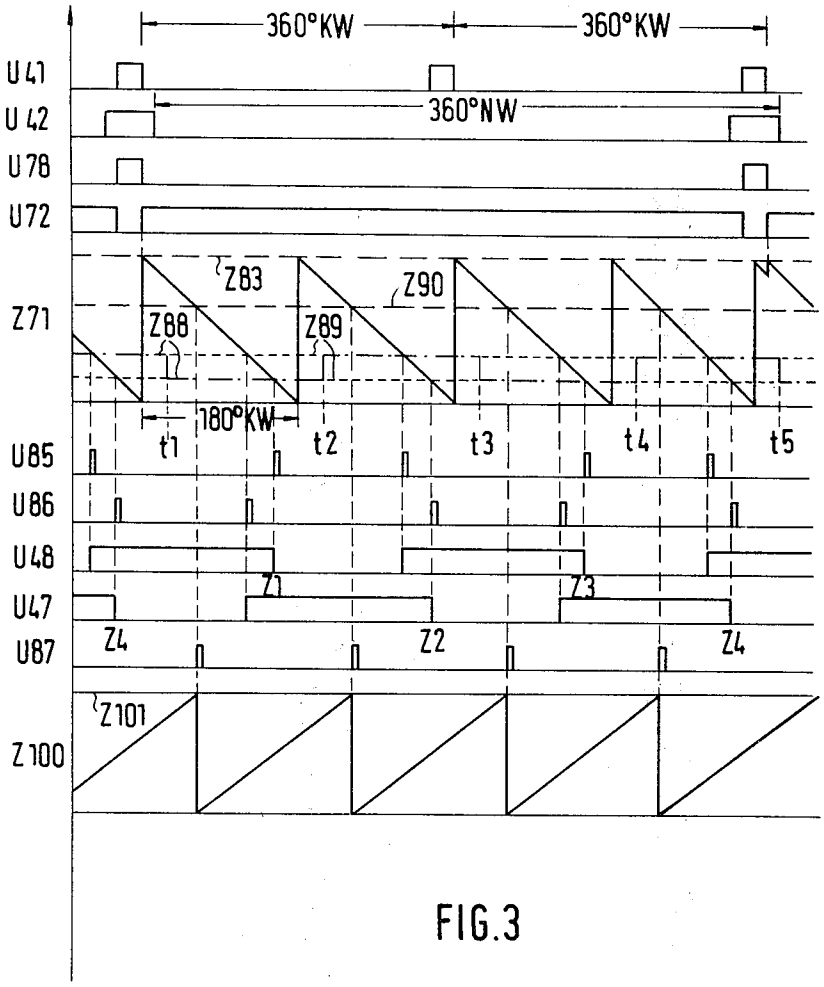

360°KW
360°KW
U41
U42
360°NW
U78
U72
Z71
Z83
Z90
Z88
Z89
180°KW
t1
t2
t3
t4
t5
U85
U86
U48
U47
U87
Z1
Z3
Z4
Z2
Z4
Z101
Z100

FIG.3

CONTROL SYSTEM FOR AN OPERATING EVENT IN A VEHICULAR POWER TRAIN

Reference to related patents, application and literature assigned to the assignee of this application:

U.S. Pat. No. 4,204,256, KLOTZNER.

U.S. Pat. No. 4,250,858, JEENICKE et al.

U.S. Pat. No. 4,063,539, GORILLE et al.

German Patent Disclosure Document DE-OS No. 29 00 111, JEENICKE et al.

Electronics, Jan. 20, 1977, page 102 et seq.

Electronic Design 1, Jan. 4, 1977, page 34 et seq.

Elektronik, 1977, issue 4, page 48 et seq.

SAE-Paper No. 750 432, Application of Microprocessors to the Automobile, page 65 et seq.

etz-b, vol. 28, 1976, issue 15, page 496 et seq.

Computer, August 1974, page 33 et seq.

RCA "User Manual for the CDP 1802 Cosmac Microprocessor MPM-201A"

RCA "Integrated Circuits, SSD-210, 4-76",

the disclosure of the foregoing patents and literature being hereby incorporated by reference.

U.S. Ser. No. 326,509, filed Dec. 2, 1981, by the inventors hereof, "SIGNAL STEERING ARRANGEMENT IN AN AUTOMOTIVE-TYPE MICROPROCESSOR SYSTEM."

The present invention relates to controlling operating events in an automotive vehicular power train system, for example controlling the ignition instant in an internal combustion engine, that is, spark advance or retardation, fuel injection quantity and/or timing, providing signals when gear shifting to a higher or lower gear should be carried out, and/or control signals for an automatic transmission or the like, in which computer equipment is utilized to determine the output as function of operating conditions or the like of an automotive vehicle.

BACKGROUND

The referenced patents and literature describe various types of microprocessor controlled systems to monitor and furnish control signals for operating events in internal combustion engines, and particularly in internal combustion engines coupled to or forming part of a power train of a vehicle. Fixed wired computers to control operating events in an automotive vehicle, or in the internal combustion (IC) engine therefor, is described in the reference U.S. Pat. No. 4,063,539; fixed wired computers or signal processors have a disadvantage with respect to microprocessor control signals in that the computer is poorly adaptable to universal use since the system is designed for a particular engine and vehicle combination, and thus cannot be individually changed to fit various types of engines or models of vehicles with which the engine is to be used, and which all introduce different parameters which vary the respective outputs from the computer, although the basic computational methods may all be the same. Microprocessor systems have the advantage of being readily adaptable to different types of engines and power train systems. They are subject to improvement, however, since they are coupled to a multiplicity of input units and also output units, and thus must retain a substantial data base and hence memory locations, which are retained in fixed memories, for example read-only memories (ROMs). Comparatively complex programs are necessary to process externally applied signals by carrying out extensive, and hence slow computational steps. If the engine operates at high speed, the accuracy of signal processing by mathematical calculations suffers, unless the number of bits is increased and the cycling or clock time is made correspondingly high. To control, for example, a fuel injection system, more than eight bits are required for accurate computation although, usually, the microprocessors which are readily adaptable for automotive use operate with eight-bit words.

The referenced U.S. Pat. Nos. 4,204,256 and 4,250,858, as well as the German Disclosure Document DE-OS No. 29 00 111, describe microprocessor-input-/output combinations in which, to relieve the microprocessor of calculation tasks, the input/output units are so arranged that they themselves can carry out computational operations and counting. In such input-/output units, a problem similar to that of a wired program arises in that, for different types of IC engines, different parameters must be sensed; the type and number of parameters may depend on the engines and on the desires or design requirements of the engine manufacturer, and thus may require processing of different signals related to different engine parameters. Yet, to permit mass production of input/output units suitable for a number of different engines and, also, to permit interchangeability, it is desirable to provide input/output units which are applicable for various types of apparatus and engines, or engine-vehicle combinations, which, looked at from point of view of signal processing, means various types of power train systems.

The Invention

It is an object to facilitate calculating operations for a microcomputer or microprocessor, while permitting rapid access by the microprocessor to parameters necessary for its calculation, while providing for high variability in processing and handling of data representing the parameters.

Briefly, the microprocessor system includes a bus system for connection to input/output units to sense, respectively, operating parameters and provide respective signals, and to supply control signals for switching stages. The input/output unit includes an angle increment counter for periodic counting of numerical values supplied over a data bus, and to generate, upon establishing of a predetermined relationship with respect to input data—for example equivalence of counted numbers—output signal for application to the microprocessor. In accordance with the invention, a switch-over or transfer switch system is provided which provides alternative angle signals, and time interval signals derived from a timing unit, to the counter in the input/output unit.

In accordance with a preferred feature of the invention, a plurality of comparators are used to control the output switching stages, for example an ignition output stage. The comparators are associated with the angle increment counters deriving signals representative of rotation of the crankshaft of the IC engine—directly or indirectly. Counting sequences being carried out by the angle increment counters thus can be utilized for control of various parameters, that is, for example to control any respective desired number of output stages. This system, then, can be used in lieu of a high-tension ignition distributor with only minor additional apparatus requirement, thus avoiding the necessity of a mechanical distributor unit, and consequent difficulties associated therewith.

Synchronization, in accordance with a feature of the invention, of the periodic counting systems in the angle increment counter, can be obtained by associating a certain angle marker transducer, coupled to the crankshaft or the camshaft of the IC engine. The ignition cycle in a four-stroke IC engine requires 720° of crankshaft rotation. Thus, the crankshaft markers which can be accurately placed on the crankshaft can be utilized for synchronization; camshaft markers then are used to determine the initiation or beginning of a 720° cycle. A simple AND-function logic gate is then all that is needed to control the further signal processing.

The system has the advantage that the calculating operations which are concerned, essentially, with determining relationships between counting states, for example equality, and counting, sensing of measured values, and outputs of control signals are removed from the microprocessor and transferred to the input/output (I/O) unit. This substantially reduces the loading on the microprocessor and permits rapid access to parameters. The control of the particular relationship to be obtain can remain within the microprocessor. The system has a high degree of flexibility in regard to sensing and processing of parameter data. The changes can be controlled from the microprocessor. Thus, the system can be used with various types of engines, having different numbers and types of input/output signal requirements, and can be readily adapted to various types of engines and power train systems.

DRAWINGS

FIG. **1** is a block diagram of a microprocessor system for an internal combustion engine, in accordance with the prior art;

FIG. **2** is a block diagram of an input/output unit in accordance with the present invention; and

FIG. **3** is a sequence of timing graphs used to explain the operation of the system and the method in accordance with the invention.

FIG. **1** illustrates a microprocessor system in which a microprocessor **10** is connected to a random access or working memory (RAM) **11**. Data which are fixed are stored in a ROM **12**; for some uses, the ROM **12** may be an erasable programmable ROM, or merely a programmable ROM (EPROM; PROM). The system further includes an input/output unit **13**. A data bus **14** connects the microprocessor **10**, RAM **11**, ROM **12**, and the input/output (I/O) control unit **13**. An address bus **15** connects the microprocessor **10**, the RAM **11** and the ROM **12**.

The data bus **14**, for example, may be a bus having eight individual lines, in dependence on the number of bits to be transferred. An additional chip selection line may be necessary in order to select one or more elemental units within the I/O unit or stage **13**. The microprocessor **10**, RAM **11** and ROM **12** are connected by a read-command line **16** in order to control information flow which is applied or stored. A write-command line **18** is provided in order to read in or record information in the RAM **11**. A program interrupt line **20** is provided, interconnecting the I/O unit **13** over terminal **21** with the microprocessor **10**. This interrupt line is used in order to interrupt a program which is being run in the microprocessor if predetermined information is placed in the I/O unit **13**. The microprocessor **10** has a "clear" command terminal **22**, which is connected to the "clear" terminal **23** of the I/O unit **13**. The clear command terminal **22** is connected to a suitable clearing stage in the microprocessor **10** which is provided to set predetermined initial conditions within the microprocessor **10**, for example completely clear conditions, or the entry of information thereinto upon starting of a new program from either ROM **12** or RAM **11**, and transfer of such conditions—if commanded—to the I/O unit **13**. The condition, in the I/O unit **13** for example, may be a complete clearance of any data therein.

A frequency generator **24** is provided, furnishing clock signals for the microprocessor **10**. The frequency derived therefrom is then, preferably, divided in suitable frequency dividing networks in the microprocessor **10** and connected to a terminal **25** forming the clock terminal of the I/O unit **13**. Power supply is obtained from an external source providing a voltage U at terminal **26**, which is connected to a voltage control or stabilization circuit **27** to provide stabilized output voltages at a terminal **28** which is connected to all elements containing electronic components. Only two such connections are shown for simplicity of the drawing.

The input/output unit is connected to an input circuit **29** which has seven inputs **30–36**, each of which is connected to an external signal or data source. The external data sources provide signals to the input circuit **29**, for processing by the I/O unit **13**, which are representative of operating parameters or conditions of the power train system.

Inputs **30, 31** are connected to a transducer system **37** which has a star or gear disk **370** coupled to the crankshaft of the IC engine, and formed with a plurality of teeth **371** at its circumference. Rotation of these teeth is sensed by a first transducer **372**. The teeth are ferromagnetic, the transducer is inductive, and change of flux within the transducer **372** causes a voltage signal to arise at the output terminal thereof. The signal sequence, which will be speed-dependent, is applied to the input of the input circuit **29**. Rather than using ferromagnetic teeth, other systems may be used which can be scanned by a transducer, for example a disk may be made which is premagnetized in strips adjacent its circumference; or a disk with openings can be used which can be scanned optically. The disk **370** additionally carries a reference marker **373**, which is scanned by a second transducer **374** to apply a referenced marker signal to the input **31**.

A further transducer system **310** is provided, coupled to input **32**. The transducer **310** has a disk **311** coupled to the camshaft of the IC engine, on which a reference marker **312** is applied. The reference marker **312** is scanned by a third transducer **313**. Of course, the teeth **371** could also be applied to the disk **311**, and scanned by the transducer **372**. The frequency of the pulse sequence then, of course, would be half.

Further information regarding the operating conditions and ambient conditions of the IC engine or the vehicle, respectively, are: temperature T; quantity of air being admitted to the induction pipe of the engine L; position of the throttle switch **38**; position of start switch **39**. The temperature-air-throttle switch position and starter switch position are connected in the form of input signals applied to terminals **33–36** of the input circuit.

Other and additional information can be applied to the input circuit, and the type of information parameters described herein is not limited to those listed; for example, additional inputs can be applied in the form of:
level of unstabilized supply voltage U;
output signals from an engine knock sensor;

output signals from an exhaust gas composition sensor;
pressure within the induction manifold;
output torque delivered by the engine;
output signals representative of engaged gearing;
and such other further information signals as may be required.

Collectively, all these further signals are indicated by a single input, schematically shown by arrow **29***a*, connected to input circuit **29**.

All the input signals, that is, the seven input signals—which, preferably, form the minimum number—as well as additional input signals at terminal **29***a* are processed in the input circuit **29** to remove noise and spurious signals therefrom, for example by filtering and, if provided in analog form, to convert the signals into digital form by suitable analog/digital converters. A suitable analog/digital converter uses a voltage controlled oscillator (VCO) for transforming analog information into digital or frequency-type information. Signal processing, noise suppression and the like, may utilize, for example, Schmitt trigger circuits. Additionally, contact-bounce suppression circuits, circuits to prevent over-voltages, protective circuits with respect to over-voltages, short circuits and the like, may also be used, as well known.

The input/output unit **13** is connected to switching output stages **49, 50** over output terminals **47, 48**. The output stages **49, 50** are ignition stages which, as is customary, include a semiconductor switch, such as a transistor, in the primary circuit of an ignition coil. The secondary circuit includes at least one spark plug or spark gap **51, 52**, respectively. A further output circuit **54** is provided to control fuel injection to inject fuel, for example, gasoline, by four injection nozzles **55–58**. The fuel injection output terminal **53**, connected to I/O unit **13**, provides the control pulses to the fuel injection unit **54**. An additional output control unit **61** is illustrated which is connected to terminals **59, 60** of the I/O unit **13**, and is utilized to control transmission shifting by selectively energizing or de-energizing hydraulic valves **62, 63**. Various other output elements may be used.

The system is described with respect to a four-cylinder engine; two ignition control systems **49, 50** are shown, and each one of the spark gaps **51, 52** represents two spark plugs, in different cylinders. The spark plugs can spark or flash over in unison; one of the spark plugs sparks at the required ignition instant, which will be before the respective piston has reached top-dead-center (TDC) position, compressing the fuel-air mixture in the respective cylinder. The other spark plug, which also flashes over, will not cause any ignition event, since, at that time, the exhaust valve from the respective other cylinder will be open and the spark will, ineffectively, occur while burned combustion gases are being exhausted.

Basic Operation: The above referenced literature has described the general operation of the system; the handbooks issued by manufacturers of microprocessors and associated apparatus are also referred to, in which the construction and circuit connection of the components are described in detail; operation and programming, likewise, is described therein, as well as variations in constructions and various connection possibilities. The referenced RCA manuals are particularly instructive.

The program stored in the ROM **12** is processed in the microprocessor **10** with respect to the information derived from the input circuit **29** and applied by the input/output unit **13**. The computed result, in the present case signals to control ignition, fuel injection, and gear shifting, is then transmitted to the output stages **49, 50, 54, 61** to carry out the desired switching commands, and effect the respective output actions. Final results and intermediate results can be stored in the RAM **11** for possible recall by the microprocessor **10**.

The number of microprocessors used, of ROMs and RAMs, is not limited to that shown in the figure and specifically described; it may be expanded in dependence on information which is to be processed, the scope of the program, and the scope of the data which are to be stored, and/or to be processed. The number of microprocessors, and storage locations in the RAM **11** as well as in the ROM **12**, will depend on the constructional type of the system, and the possibility of long-time memory as well as short-time memory and buffer storage, and the availability of respective storage locations.

FIG. **2** illustrates a portion of the input/output unit **13**, arranged in accordance with the present invention. Terminal **40**—see also FIG. **1**—has a pulse-type speed signal applied thereto. Terminal **40** is connected to a frequency multiplying stage **70** which, in turn, is connected to the clock input C of a crankshaft angle increment counter **71**. Terminals **41, 42**—see also FIG. **1**—carrying reference marker signals are connected over a selection input circuit **72**, the output of which is connected to an OR-gate **73** which is connected to the loading pulse input PE of the counter **71**. The two terminals **41, 42** in the selection circuit **72** are selectively connectable by transfer switches **74, 75** either directly or over an inverter **76, 77**, respectively, to an AND-gate **78**. The output from the AND-gate **78** is selectively connectable over a further switch **79** directly or over an inverter **80** to the OR-gate **73**. The transfer switches **74, 75, 79** may be formed, for example, by transmission gates and are controlled from the data bus **14** through a transfer switch decoding stage **81**. The decoding stage **81** has a control input **82**.

The overflow output CO of the counter **71** is connected to the other input of the OR-gate **73**. A buffer memory **83** is connected to the data bus **14**. The buffer memory **83** has an entry or transfer control terminal **84**. The count inputs of the counter **71** are connected to count comparison inputs of three comparators **85, 86, 87**. Comparison count inputs of the comparators **85, 86, 87** are connected through buffer storage or memories **88, 89, 90** which, respectively, are controlled by signals at terminals **91, 92, 93**, the buffer memories being connected to the data bus **14**. The count outputs of the counter **71** are connected through a gate **68**, which has a control terminal **69**, to the data bus **14**.

The outputs of the comparators **85, 86** control, respectively, each a JK flip-flip (FF) **94, 95** which form the output stage control elements for the ignition control unit **49, 50**. The J inputs and the K inputs of the FFs **94, 95** are connected to control terminals **97, 98** and **66, 67**, respectively.

In accordance with a feature of the invention, a transfer switch **99** is provided, having one terminal connected to the output of the comparator **87**, and the other to a timing element **108** formed by a counter. The transfer switch **99** has its switching element connected to the reset input R of a counter **100** as well as to the SET input of a buffer store **101**. Transfer switching of the switch **99** is controlled from the data bus **14** over a transfer switch decoding stage **102**. The decoding stage **102** is controlled from a control terminal **103**. The count

outputs of the counter **100** are connected to the count inputs of the buffer store **101**. The count outputs of the buffer store **101** are connected over a gate **104**, which has a control terminal **105**, to the data bus **14**. The clock input C of the counter **100** can be selectively connected, under control of the data bus, with terminals **40**, **43** or **44** (FIG. **1**) or other parameter-dependent counting frequencies. The data bus **14** is additionally connected over a buffer memory **106**, which has a control terminal **107**, with the count inputs of the timing counter **108**. The clock input C of the counter **108** is connected over terminal **109** with a counting clock frequency. Various clock frequencies could be connected to the terminal **109**, under control of data derived from the data bus **14**, for example under control of a further decoding circuit. Reference is made to the U.S. Pat. Nos. 4,250,858 and 4,204,256, as well as to the DE-OS No. 29 00 111, for further details of control of the timing counter **108**. The counter overflow terminal CO of the counter **108** is connected with the SET input PE thereof and, additionally, or alternatively, can be connected to the output of the comparator **87** by the transfer switch **99** with the RESET input of the counter **100** in dependence on the position of the switch **99**.

The control terminals **66**, **67**, **82**, **84**, **91**, **92**, **93**, **97**, **98**, **103**, **105**, **107** receive control signals through a decoding device—not shown—as described in the aforementioned referenced patents and German Disclosure Document to determine the sequencing of the control signals in dependence on the program which is run in the microprocessor. Reference is also made to the literature, and particularly the manufacturer's literature how sequencing control signals can be derived from a microprocessor in which a program is being run, and in which the control signals depend on the state of respective program conditions.

Operation, with reference to FIG. **3**: The crankshaft angle increment counter **71** is set to the numerical value **V83** stored in the buffer memory **83** when a signal is derived from the selection circuit **72** each time after two full rotations of the crankshaft, that is, after 720° rotation thereof. Upon being set to the value **Z83**, the counter counts down in the rhythm of the angle increments as determined by the teeth **371**, transduced by transducer **372**, and available at the terminal **40** (FIG. **2**). When the counter has reached the value null or zero, an overflow signal at the counter overflow terminal CO thereof or a signal from the OR-gate **73** resets the counter back to the count number **Z83**, and starts anew to count down. The count number **Z83** is so set that the angle increment counter **71** will have that number of count cycles occur therein which corresponds to the numbers of cylinders of the IC engine within a range of 720° of rotation of the crankshaft. This is effective for all four-stroke IC engines. The illustrated example refers to a four-cylinder IC engine. Synchronization is effected after each 720° of crankshaft rotation by the selection circuit **72**, that is, if for example due to malfunction, interference, noise or disturbance pulses, an error should have occurred, the error will be eliminated after each 720° rotation of the crankshaft. This is illustrated in the first cycle of FIG. **3**. The arrangement is used to generate an internal or electronic reference marker or reference marker signal. Since the marker **373** coupled to the disk **370** (FIG. **1**) connected to the crankshaft of the engine due to the higher speed provides more precise signals **U41**, and this marker occurs at each 360° of crankshaft rotation, the marker **312** on the camshaft is utilized in order to determine the 720° range of crankshaft rotation. Markers **373** and **312** are so arranged that generation of a signal **U42**, from marker **312**, also causes generation of a signal **U41** from marker **373**. The signal **U42** is longer. Upon simultaneous occurrence of signals **U41** and **U42**, the output of the AND-gate **78** provides a synchronizing signal **U78**, which characterizes the beginning of a new crankshaft revolution cycle of 720°—two revolutions.

The inversion possibilities in the selection circuit **72** are utilized to match the system to various types of transducers **37**, **310**. If, for example, the signal **U41** would be generated as a negative signal, then the transfer switch **74**—under program control—is changed over, so that the signal can be inverted by inverter **76**. Similar considerations apply to the signal **U42**. Inverter **79** is used to determine that flank of the signal **U41** at which the counter **71** should be set. In the present example, counter **71** is set with a positive flank, and this setting should occur at the second flank of the signal **U41**. Thus, inverter **80** must be used in order to invert the signal **U78**. If the counter **71** is to be set by the first flank of the signal **U41**, transfer switch **79** must be changed over. The selection circuit **72**, thus, through the program of the microprocessor, can be utilized to match the system to any type of transducer system, by entering respectively appropriate code words into the decoding stage **81**. Circuit **72**, thus, functions as a signal polarity selection circuit under control of decoder **81**.

The ignition output control stages **49**, **50**, connected to terminals **47**, **48**, are controlled by the comparators **85**, **86**. Similarly, the output stages **54** for fuel injection, and **61** for gear shifting or transmission changes can be controlled by similar comparators. Numerical values **Z88**, **Z89**—FIG. **3**—are determined in the microprocessor, in dependence on the parameters to be sensed, and applied over the data bus **14** to the buffer memories **88**, **89**. Storage is controlled by control signals applied to the respective terminals **91**, **92**. The value of the number **Z88**, **Z89** is changed at the time instants **T1** to **T5** in order to provide data characterizing the beginning and the end of the closing time of the ignition switch controlling current flow through an ignition coil, and contained within the stages **49**, **50**. FIG. **3** illustrates the value **Z88** as a chain-dotted line, and the numerical value **Z89** as a dotted line.

Upon equality of the applied numerical values, comparators **85**, **86** provide output pulses **U85**, **U86** which cause the state of the JK-FFs **94**, **95** to change in dependence on the control signals applied to the respective terminals **66**, **67**, **97**, **98**. The output signals **U47**, **U48** determine the closing time or dwell time of the ignition output stages **49**, **50**. Signal **U47** is applied to the ignition system associated with cylinders two and four of the four-cylinder engine, and signal **U48** controls the ignition system associated with cylinders one and three. The ignition instants, controlling generation of the spark at the respective spark plug, are indicated by the designation **Z1**, **Z2**, **Z3**, **Z4**. In known manner, the spark plugs of cylinders one and three on the one hand, and of cylinders two and four on the other, are simultaneously energized to have an ignition spark flash over. This ignition spark will ignite the air-fuel mixture in the closed cylinder, which is just about to change from the compression stroke to the power stroke, and will be ineffective with respect to the burned combustion exhaust gases of the other cylinder; in other words, the ignition spark will occur in an ambient surrounding

which, in one cylinder, contains an ignitable mixture, and in the other cylinder contains exhaust gases. The control signals on the terminals **66, 67, 97, 98** are applied at uniform intervals between two closing time periods, that is, in the FF **94** for example at the time instants t_1, t_3, t_5, etc. This permits setting an extinction determined by the program, in which the time instants are determined by the output signals from comparators **85, 86**. Further possibilities of invasion of the system, resulting in instantaneous setting and extinction, can be obtained by the program, for example by direct setting and resetting inputs having higher priority. The system described permits use of a single counter **71** which is computer controlled to then in turn control a plurality of output stages while avoiding the necessity of a mechanical high-voltage distributor, permitting, further, overlap of closing times. A specific association of cylinders to the computer is not needed since this is obtained within the I/O circuit **13**.

The number of the output stages controlled in this manner by a suitable number of comparators, of course, is not limited to two output stages, but can be expanded as desired; even a larger number of comparators can readily be controlled by the counter **71** which is the only counter needed to generate the respective trigger signals.

The comparator **78** is used to generate rotary angle intervals during which sequences of signals which depend on operating parameters are to be processed. In the present example, that is, of a four-cylinder IC engine, the intervals are 180° intervals. These intervals can be changed, as desired, under computer control, if different numerical values **Z90** are applied through the buffer memory **90** from the data bus **14**. The angle signals **U87**—FIG. **3**—generated in the comparator **87** are used in the counter **100** as reset signals which, each time, start a new count cycle in the counter **100**. During any such count cycle, a parameter-dependent frequency is counted, for example the quantity of air induced through the induction pipe of the engine, as represented by a pulse signal of frequency dependent on the air quantity. The count state **Z101** is transferred, shortly before reset, into the buffer store **101** and, as needed, can be interrogated by the microprocessor **10** by applying an interrogation control signal to the gate control terminal **105**, and then interrogating the buffer store **101** through gate **104**. Thus, a signal which has been derived from the counted frequency corresponding to air quantity, counted during an angular interval, can be obtained which is directly representative of fuel injection time.

Other frequencies depending on operating or ambient parameters, for example speed-dependent frequencies or temperature-dependent frequencies have to be counted during an angular interval corresponding to a fixed time interval. In this case, the decoding stage **102** causes change-over of the transfer switch **99** so that the time interval to limit the counting cycle of the counter **100** is determined by the timing counter **108**. This time interval can be varied by applying either different counting values to the timing counter **108** over buffer memory **106** as controlled by control terminal **107** or by changing the counting frequency at the terminal **109**. In dependence on the count number provided by the buffer memory **106**, or the count rate as determined by input **109**, a reset signal for the counter **100** is generated by the timing element formed by counter **108**.

The system is highly flexible, since different parameters derived, for example, from the terminals **40, 43, 44**, can be counted in a single counter **100** either to

(a) during a variable crankshaft angle interval—as determined by comparator **87**, or

(b) during a variable time interval, as determined by a timing element, formed by timing counter **108**.

The count result derived from counter **100** is then stored in the buffer store **101**, for interrogation when required. The I/O unit **13** thus is rendered much more versatile and variable with respect to sensing of parameters, and can readily be adapted to different types of IC engines, in different types of power train systems for various types of vehicles, as required, for example, by variable demands of different automotive manufacturers.

The respective count states of the counters, as well as the operating states of the output stages, can of course be interrogated by suitable control signals applied for example over the data bus **14**—see, for example, the referenced U.S. Pat. Nos. 4,204,256, 4,250,858 and the German Disclosure Document DE-OS No. 29 00 111. Such interrogation is shown in the present application only for the counter **100** and for the counter **71**, by gates **104** for counter **100**, and **68** for counter **71**, respectively.

Various changes and modifications may be made within the scope of the inventive concept.

We claim:

1. For combination with a vehicular power train,

a control system to control an operating event within said power train and having a rotating shaft, said control system having

a microprocessor unit (**10**);

an input/output (I/O) unit (**13**);

a data bus system (**10**) interconnecting the microprocessor unit and the input/output unit;

a plurality of input sensor elements (**37, 310, 372, 374, 313**, T, L, **38, 39, 29***a*) providing sensing signals representative of operating parameters of the power train, connected to and providing said sensing signals to the input/output unit,

one of said input sensor elements (**370, 372**) forming a crankshaft angle increment transducer (**37**) providing a train of crankshaft increment signals;

a plurality of output stages (**49, 50, 54, 61**) for carrying out operating commands connected to and controlled by the input/output unit;

a crankshaft angle increment counter (**71**) connected to receive said crankshaft angle increment signal train and counting the pulses of said pulse train at a rate determined by the frequency of said pulse train;

a first comparator (**83**) connected to the angle increment counter and to the data bus to receive a comparison signal from the data bus (**14**) and providing a first output signal when the count output from said angle increment counter (**71**) and from the data bus have a predetermined relationship,

said output signal being connected to at least one of the output stages to control operation thereof;

a second comparator (**87**) connected to the angle increment counter (**71**) and to the data bus (**14**) to receive a comparison signal from the data bus and providing a second output signal when the count output from the angle increment counter and from the data bus have a second predetermined relationship;

a second counter (100) having its output connected to the data bus (14) to provide output signals thereto for processing in the microprocessor unit (10) in accordance with a selected parameter or value, as determined by the signal applied to the second comparator (87) from the data bus,

and comprising, in accordance with the invention,

a timing circuit (108) providing timing signals;

and transfer switch means (99) having its switching state controlled by data from the data bus (14) and transferring to the second counter (100), selectively, and in accordance with the switching state thereof,

(a) the output signals from said second comparator (87), or

(b) the timing signals from the timing circuit (108),

to control the counting cycle of the second counter (100) selectively by

(a) the parameter-dependent pulse train derived from the second comparator (87), as counted by said angle increment counter (71), or

(b) the timing interval of the timing circuit (108),

and wherein the angle increment counter (71), the second counter (100), said first and second comparators (85, 87) and the timing circuit (108) form part of the input/output unit, to permit the input/output unit to provide data to the data bus, and hence to the microprocessor, selectively, based on signals processed by a single shaft angle increment counter (71) or, selectively, based on time intervals determined by said timing circuit (108).

2. System according to claim 1, wherein the timing circuit (108) is a counter connected to and controlled by the data bus (14), said data bus providing data to said counter controlling at least one of: counting rate; count number.

3. System according to claim 1, further comprising at least one additional comparator (86) connected to the angle increment counter and to the data bus to receive a comparison signal from the data bus (14), and providing an additional output signal when the count output from the angle increment counter (71) and from the data bus have an additional predetermined relationship, the output signal from the additional comparator being connected to at least a further one of the output stages (50, 54, 61) to control the operation thereof.

4. System according to claim 1, wherein the power train includes a camshaft;

said input sensor elements include a camshaft angle transducer (310);

and a selection circuit (72) is provided, receiving both said crankshaft angle signal pulse train and said camshaft angle signal pulse train, said selection circuit includes an AND-function circuit (78) providing a synchronization signal, said synchronization signal being connected to and synchronizing the angle increment counter (71).

5. System according to claim 4, wherein the camshaft angle transducer provides output signals in pulse form having a greater pulse width than the output signals derived from the crankshaft angle increment transducer, the AND-function circuit providing said synchronization signal when there is overlap between the respectively applied signals.

6. System according to claim 4, wherein the selection circuit (72) further includes selectively connectable direct and inverting inputs, and controlled transfer switch means (74, 75, 79) controlled by data from said data bus (14) to, selectively, connect direct or inverting inputs to the respective transducers and, selectively, to the crankshaft angle increment counter for matching of polarity of signals supplied by respectively different types of transducers connectable in said system.

7. For combination with a vehicular power train, a control system to control an operating event within said power train, said power train having an engine including a crankshaft and a camshaft;

said control system having an input sensor element (370, 372) coupled to the crankshaft of the engine and forming a crankshaft angle increment transducer (37) providing a train of crankshaft increment signals;

a crankshaft angle increment counter (71) connected to receive said crankshaft angle increment signal train and counting the pulses of said pulse train at a rate determined by the frequency of said pulse train;

a reference marker (373) and reference marker transducing means (374) coupled to said crankshaft and providing a marker signal representative of a predetermined angular position of said crankshaft;

a camshaft angle transducer (310) coupled to the camshaft of the engine and operating at a speed different from said crankshaft;

and a selection circuit (72) receiving at least one of said crankshaft signals and said camshaft angle signals,

said selection circuit including an AND-function circuit (78) providing a synchronization signal, said synchronization signal being connected to and synchronizing the angle increment counter (71).

8. System according to claim 7, wherein the camshaft angle transducer provides output signals in pulse form having a greater pulse width than the output signals derived from the crankshaft angle increment transducer, the AND-function circuit providing said synchronization signal when there is overlap between the respectively applied signals.

9. System according to claim 7, wherein the selection circuit (72) further includes selectively connectable direct and inverting inputs, and controlled transfer switch means (74, 75, 79) controlled by data from said data bus (14) to, selectively, connect direct or inverting inputs to the respective transducers and, selectively, to the crankshaft angle increment counter for matching of polarity of signals supplied by respectively different types of transducers connectable in said system.

10. System according to claim 7, wherein the marker on the camshaft rotates through 720° of crankshaft angle rotation to provide positive association of counting events with respect to the strokes of a four-stroke engine regardless of spurious or interference or noise pulses.

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